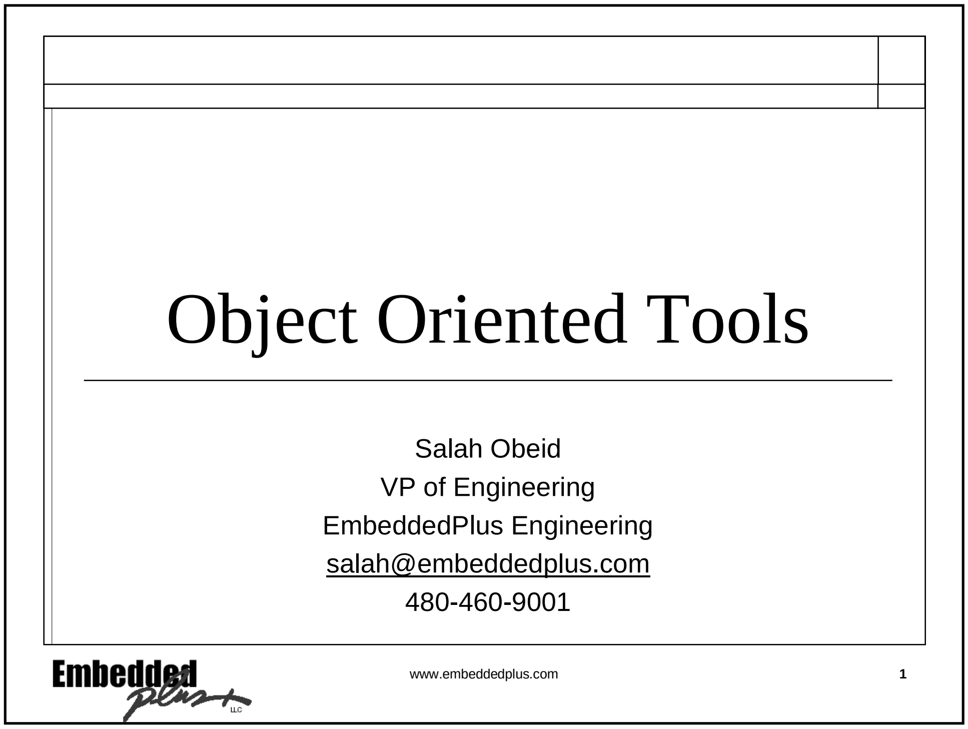

Object Oriented Tools

Salah Obeid
VP of Engineering
EmbeddedPlus Engineering
salah@embeddedplus.com
480-460-9001

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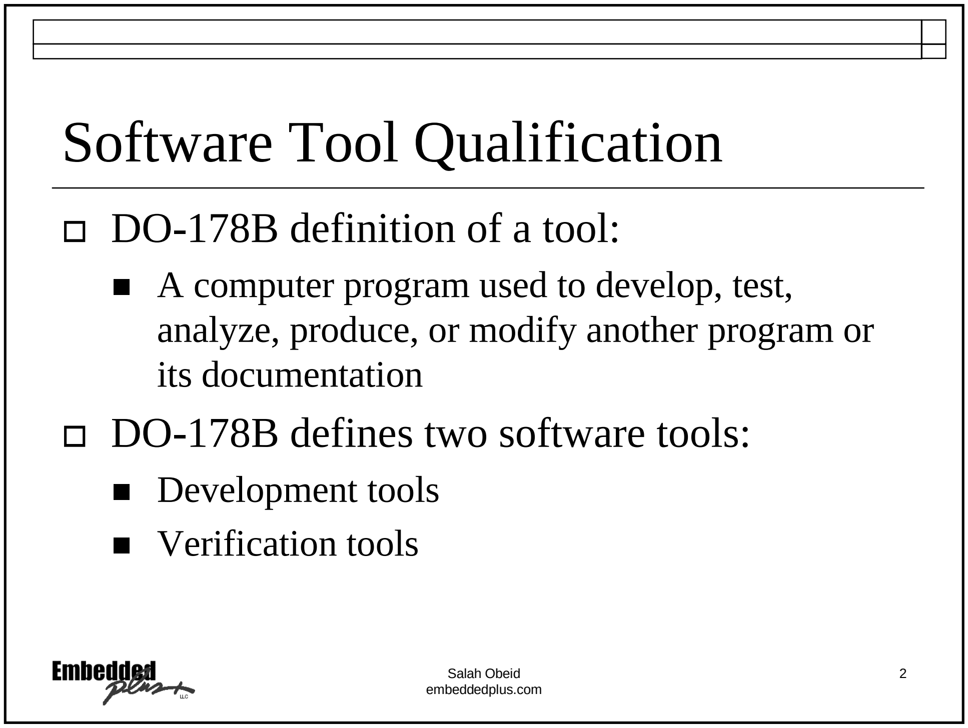

Software Tool Qualification

- DO-178B definition of a tool:
  - A computer program used to develop, test, analyze, produce, or modify another program or its documentation
- DO-178B defines two software tools:
  - Development tools
  - Verification tools

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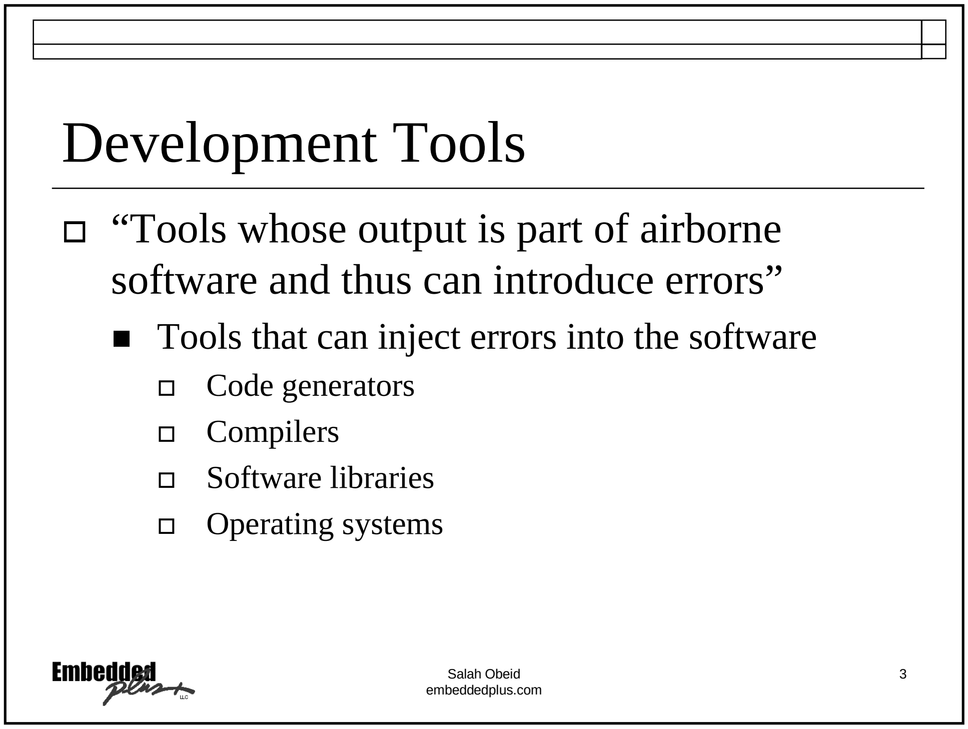

Development Tools

- □ "Tools whose output is part of airborne software and thus can introduce errors"
  - ■ Tools that can inject errors into the software
    - □ Code generators
    - □ Compilers
    - □ Software libraries
    - □ Operating systems

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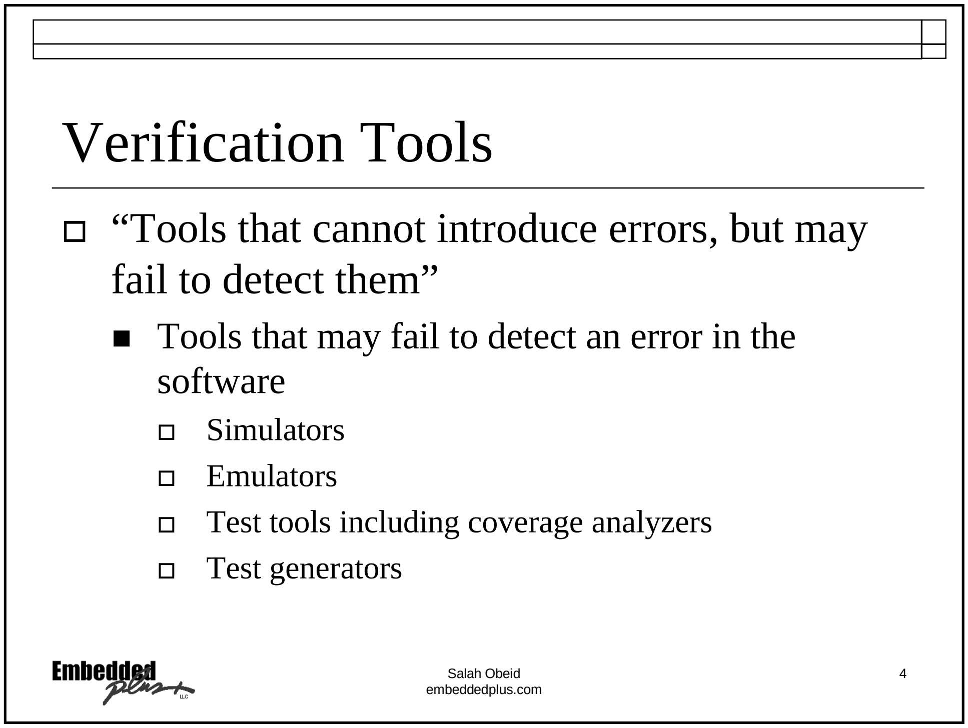

Verification Tools

- □ "Tools that cannot introduce errors, but may fail to detect them"
  - ■ Tools that may fail to detect an error in the software
    - □ Simulators
    - □ Emulators
    - □ Test tools including coverage analyzers
    - □ Test generators

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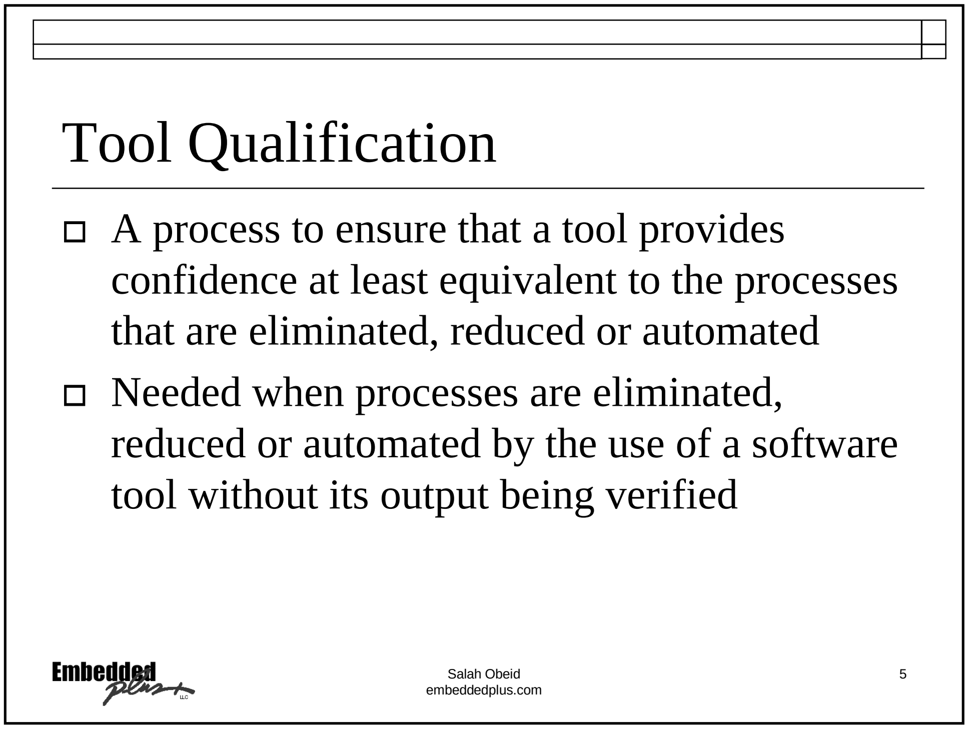

Tool Qualification

- □ A process to ensure that a tool provides confidence at least equivalent to the processes that are eliminated, reduced or automated
- □ Needed when processes are eliminated, reduced or automated by the use of a software tool without its output being verified

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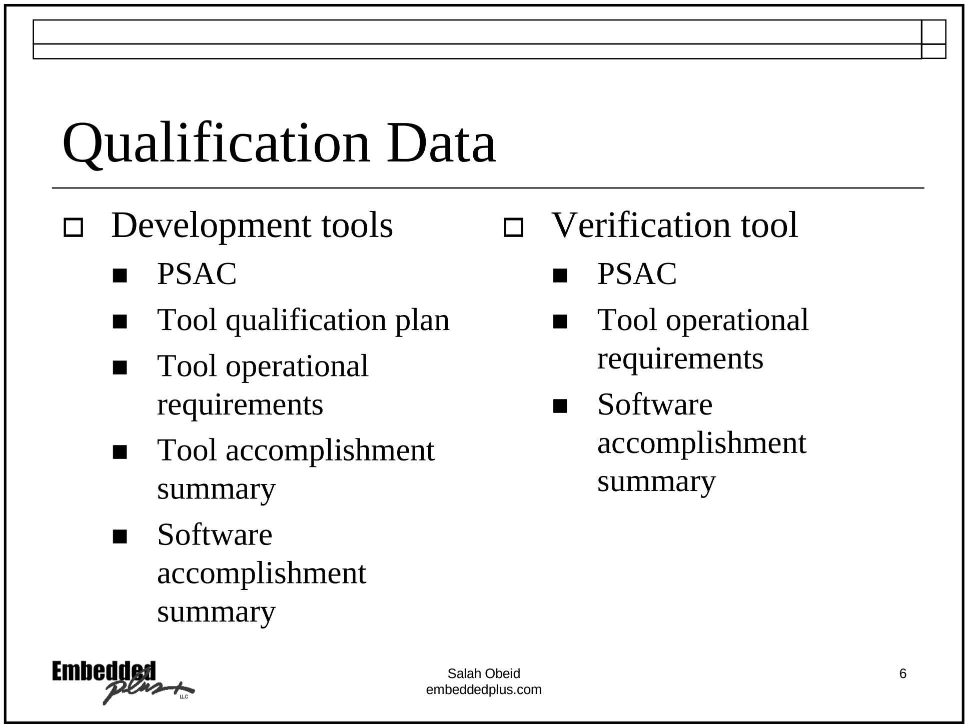

Qualification Data

- □ Development tools
  - ■ PSAC
  - ■ Tool qualification plan
  - ■ Tool operational requirements
  - ■ Tool accomplishment summary
  - ■ Software accomplishment summary
- □ Verification tool
  - ■ PSAC
  - ■ Tool operational requirements
  - ■ Software accomplishment summary

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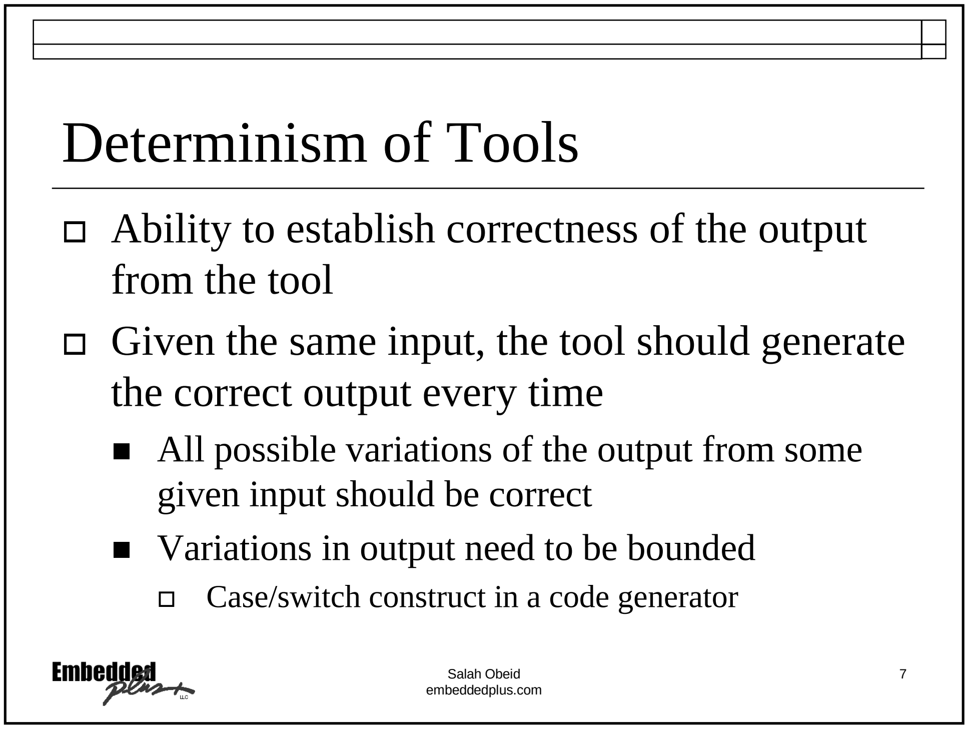

Determinism of Tools

- □ Ability to establish correctness of the output from the tool
- □ Given the same input, the tool should generate the correct output every time
  - ■ All possible variations of the output from some given input should be correct
  - ■ Variations in output need to be bounded
    - □ Case/switch construct in a code generator

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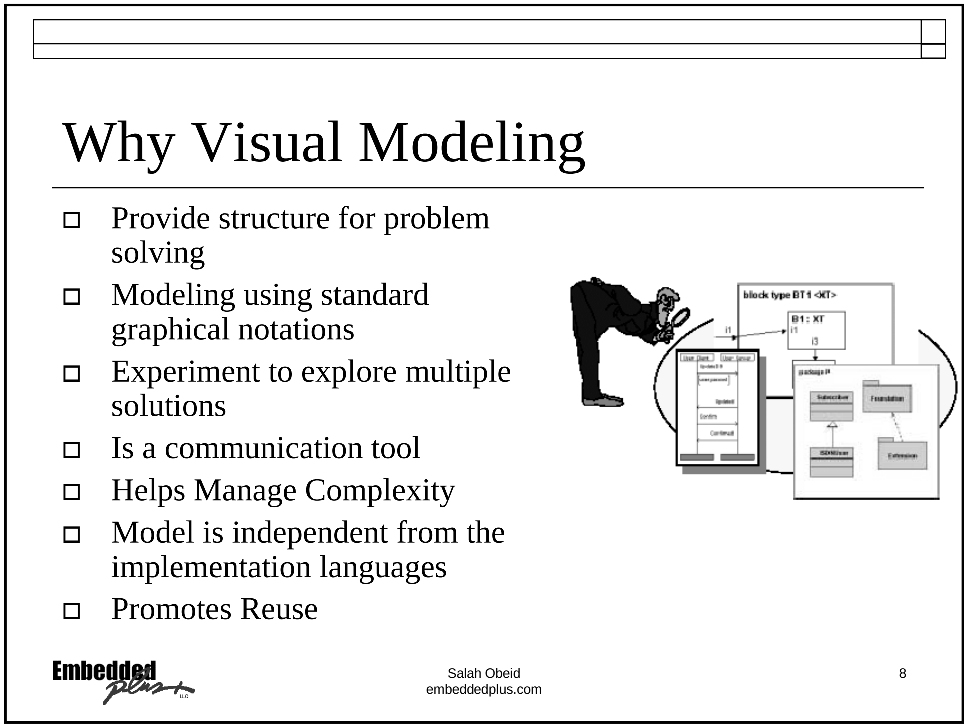

Why Visual Modeling

- □ Provide structure for problem solving
- □ Modeling using standard graphical notations
- □ Experiment to explore multiple solutions
- □ Is a communication tool
- □ Helps Manage Complexity
- □ Model is independent from the implementation languages
- □ Promotes Reuse

block type BT1 <XT>
B1 : XT
i1
i1
i3
package P
Subscriber
Foundation
ISDNUser
Extension
Update
Confirm
Continue

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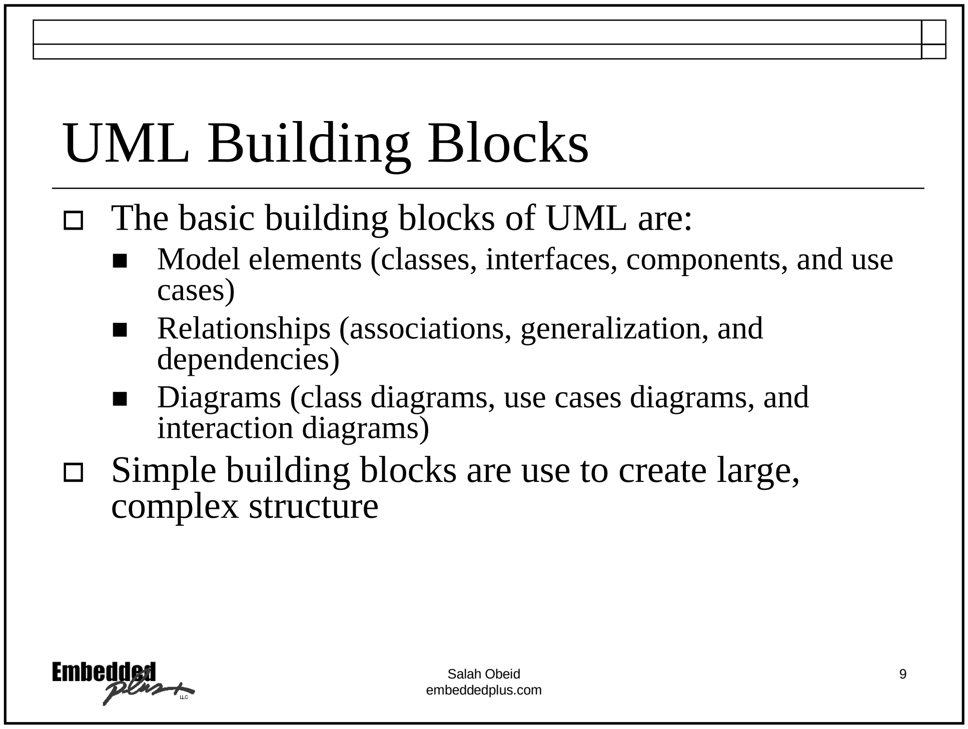
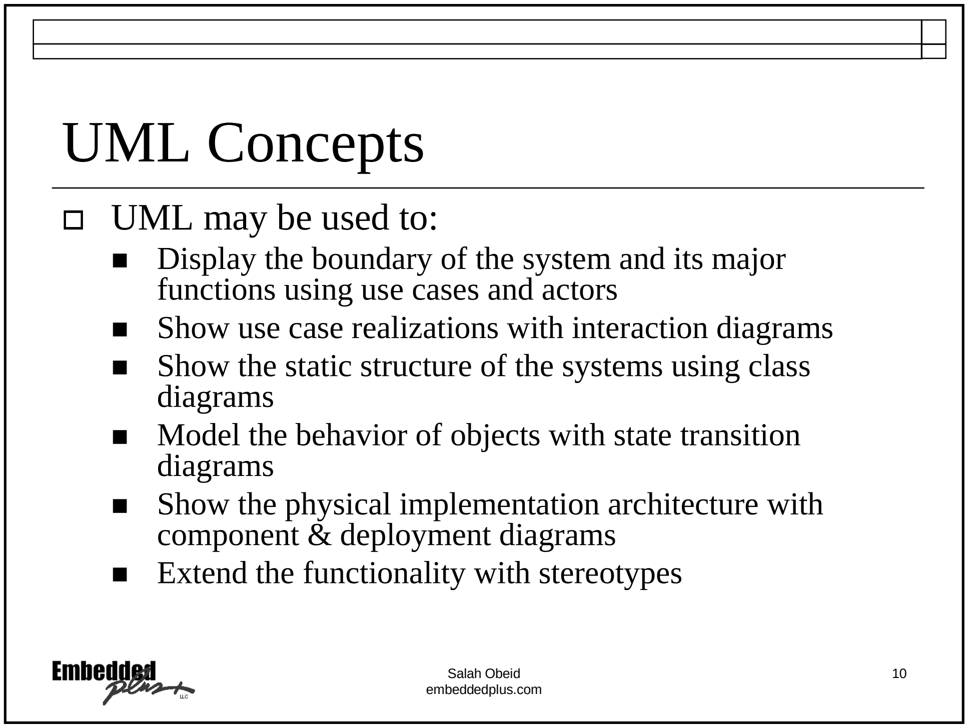


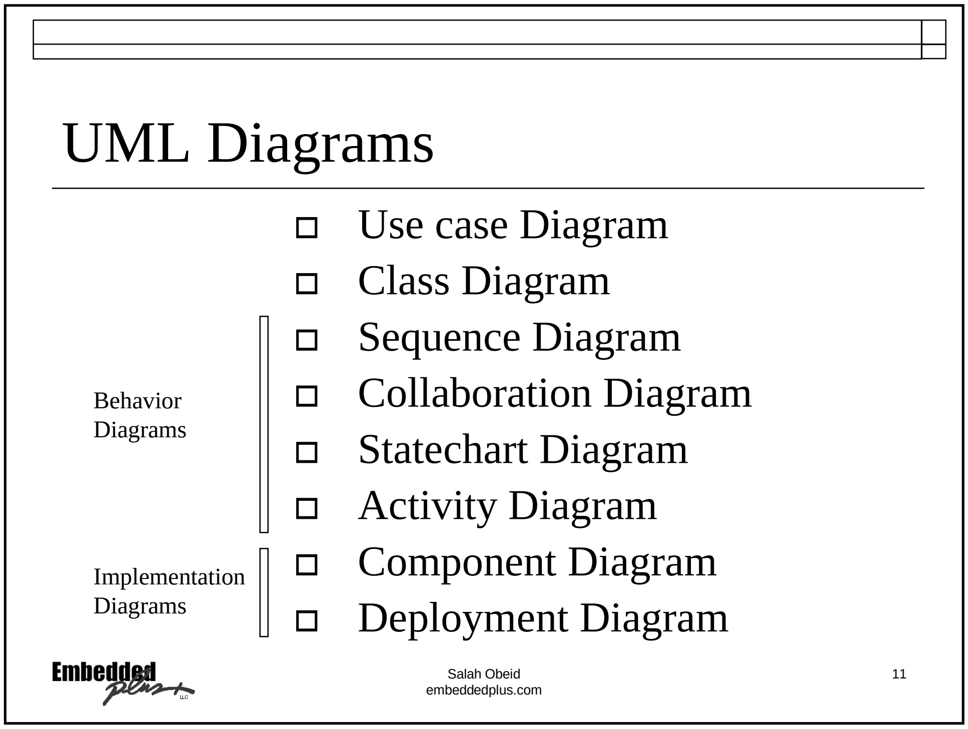
UML Building Blocks

- □ The basic building blocks of UML are:
  - ■ Model elements (classes, interfaces, components, and use cases)
  - ■ Relationships (associations, generalization, and dependencies)
  - ■ Diagrams (class diagrams, use cases diagrams, and interaction diagrams)
- □ Simple building blocks are use to create large, complex structure



UML Concepts

- □ UML may be used to:
  - ■ Display the boundary of the system and its major functions using use cases and actors
  - ■ Show use case realizations with interaction diagrams
  - ■ Show the static structure of the systems using class diagrams
  - ■ Model the behavior of objects with state transition diagrams
  - ■ Show the physical implementation architecture with component & deployment diagrams
  - ■ Extend the functionality with stereotypes



UML Diagrams

- □ Use case Diagram
- □ Class Diagram

Behavior Diagrams

- □ Sequence Diagram
- □ Collaboration Diagram
- □ Statechart Diagram
- □ Activity Diagram

Implementation Diagrams

- □ Component Diagram
- □ Deployment Diagram

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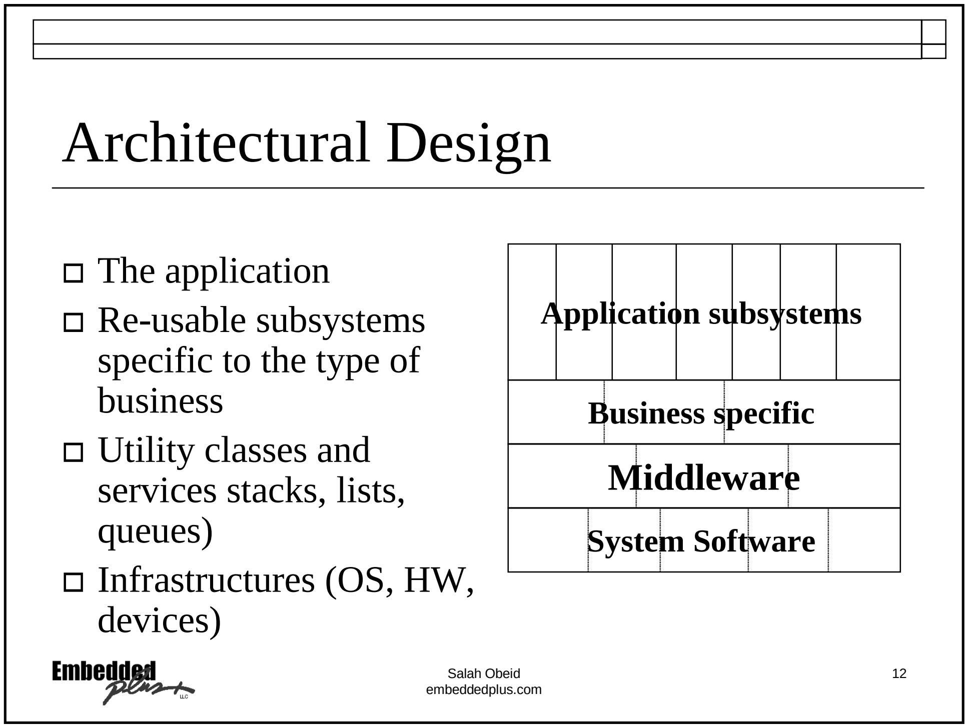

Architectural Design

- □ The application
- □ Re-usable subsystems specific to the type of business
- □ Utility classes and services stacks, lists, queues)
- □ Infrastructures (OS, HW, devices)

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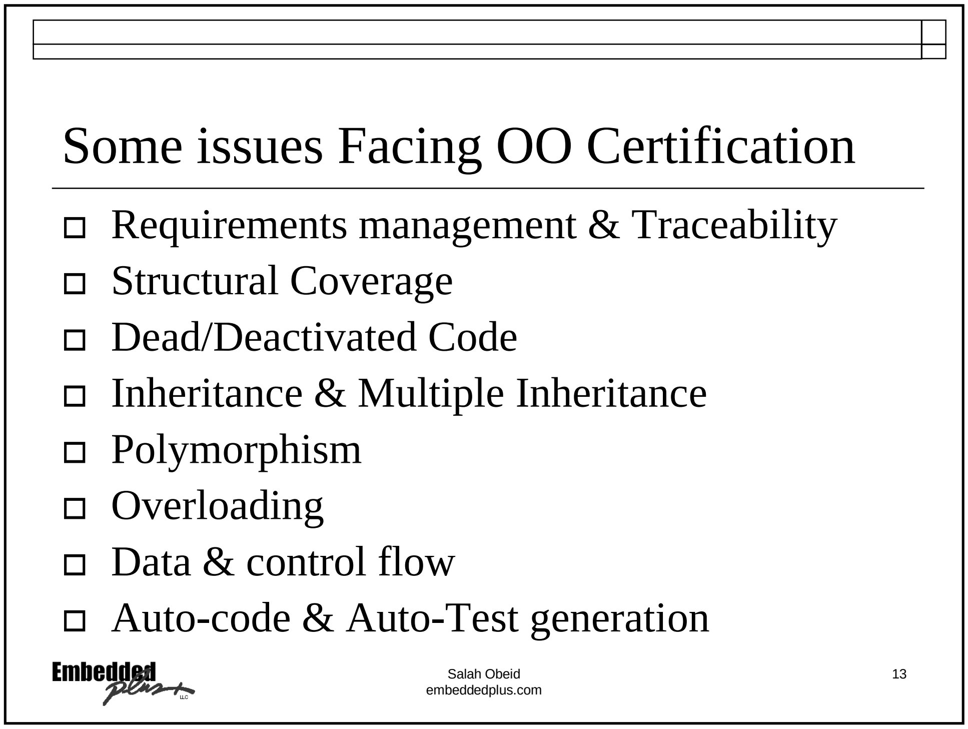

Some issues Facing OO Certification

- □ Requirements management & Traceability
- □ Structural Coverage
- □ Dead/Deactivated Code
- □ Inheritance & Multiple Inheritance
- □ Polymorphism
- □ Overloading
- □ Data & control flow
- □ Auto-code & Auto-Test generation

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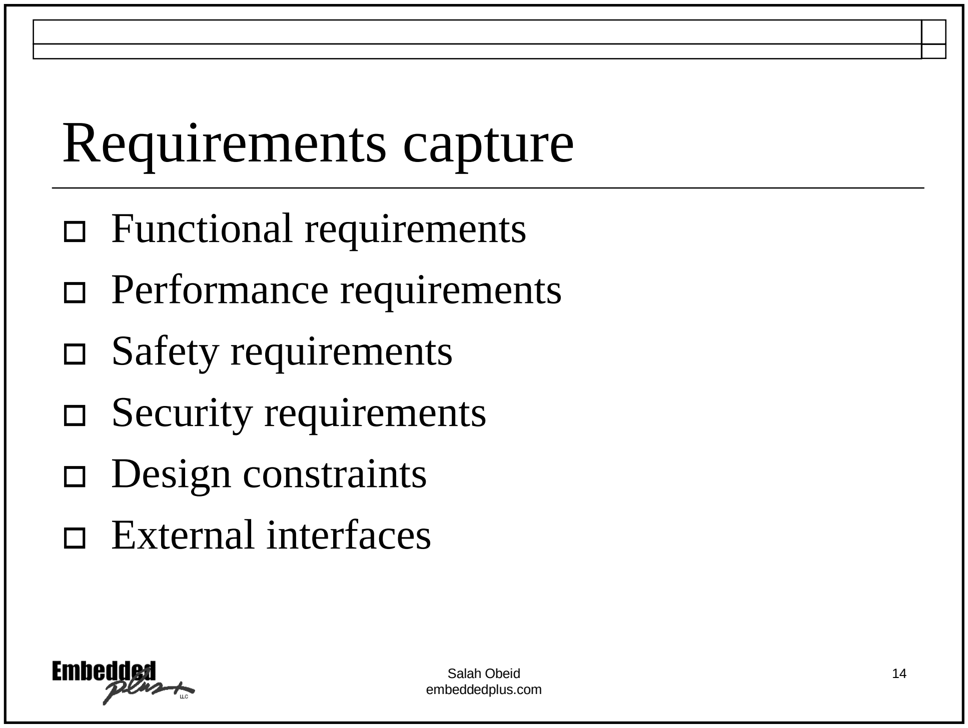

Requirements capture

- □ Functional requirements
- □ Performance requirements
- □ Safety requirements
- □ Security requirements
- □ Design constraints
- □ External interfaces

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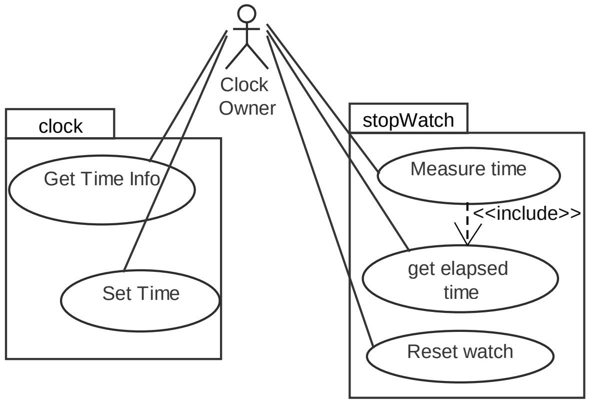
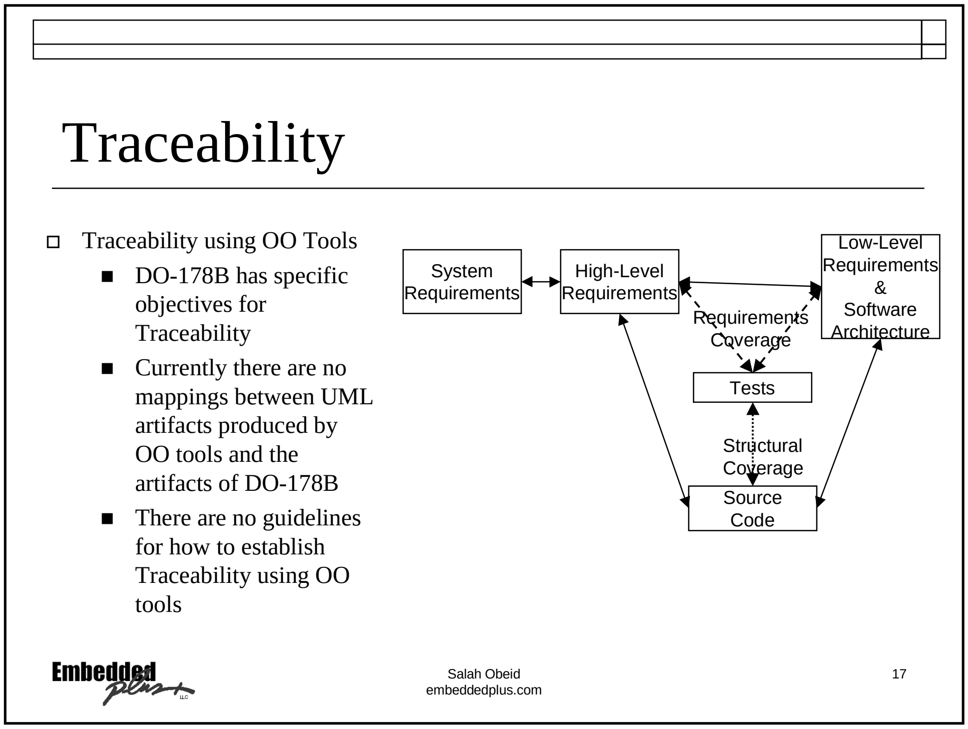
Use Cases



Use Case Description

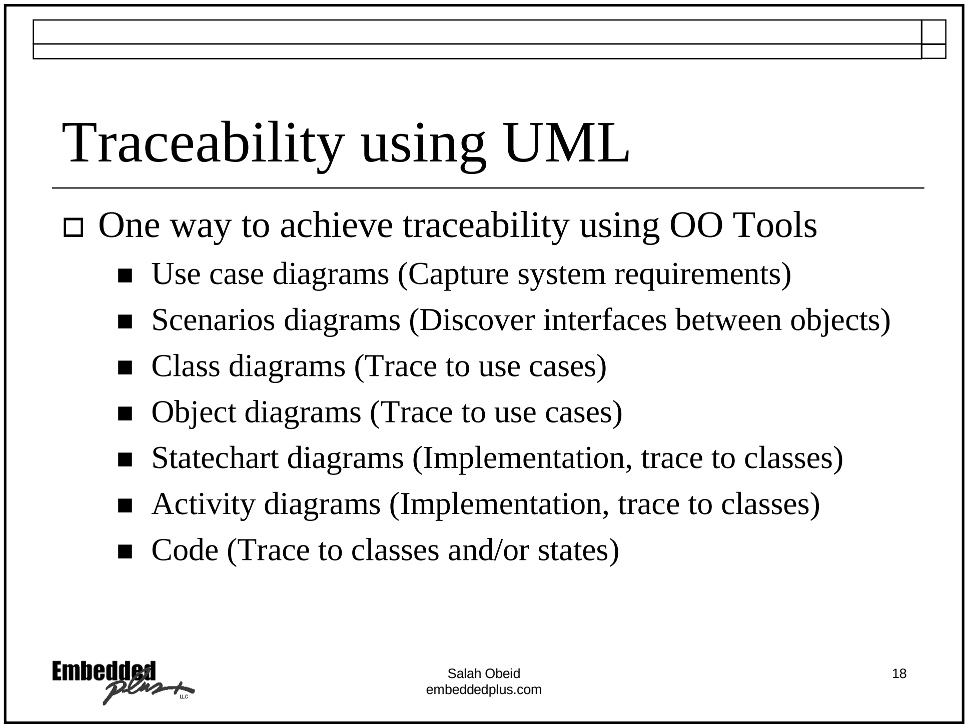
- □ Name:
- □ Actors:
- □ Pre-conditions:
- □ Begins:
- □ Description:
- □ Ends:
- □ Exceptions:
- □ Post condition:



Traceability

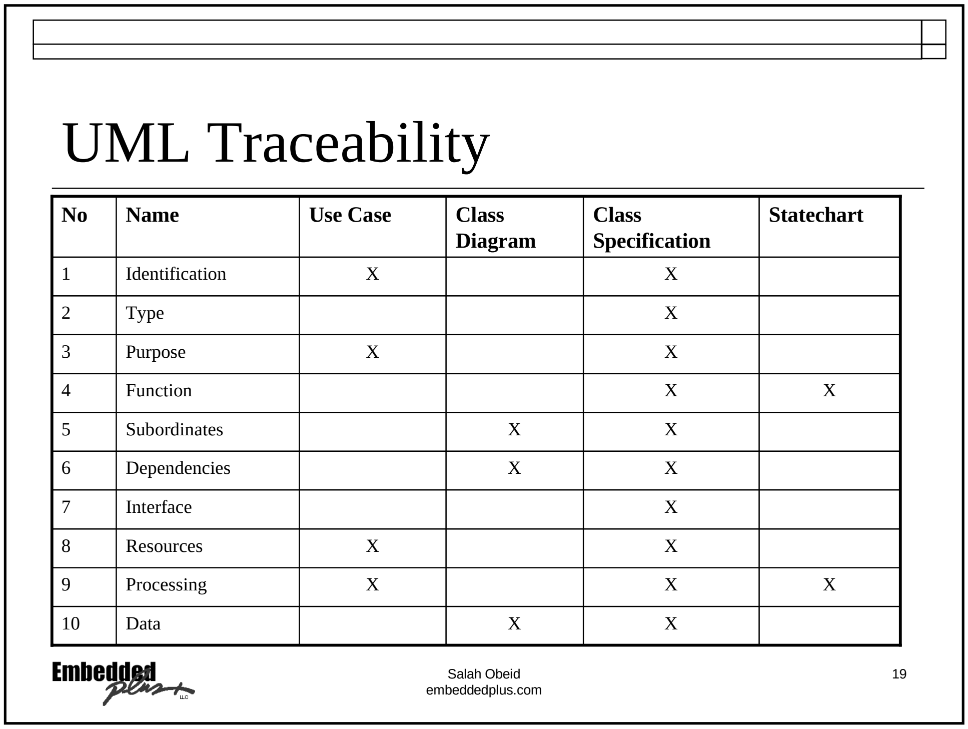
- Traceability using OO Tools
  - DO-178B has specific objectives for Traceability
  - Currently there are no mappings between UML artifacts produced by OO tools and the artifacts of DO-178B
  - There are no guidelines for how to establish Traceability using OO tools

System Requirements
High-Level Requirements
Low-Level Requirements & Software Architecture
Requirements Coverage
Tests
Structural Coverage
Source Code



Traceability using UML

- One way to achieve traceability using OO Tools
  - Use case diagrams (Capture system requirements)
  - Scenarios diagrams (Discover interfaces between objects)
  - Class diagrams (Trace to use cases)
  - Object diagrams (Trace to use cases)
  - Statechart diagrams (Implementation, trace to classes)
  - Activity diagrams (Implementation, trace to classes)
  - Code (Trace to classes and/or states)



UML Traceability

No	Name	Use Case	Class Diagram	Class Specification	Statechart
1	Identification	X		X	
2	Type			X	
3	Purpose	X		X	
4	Function			X	X
5	Subordinates		X	X	
6	Dependencies		X	X	
7	Interface			X	
8	Resources	X		X	
9	Processing	X		X	X
10	Data		X	X	

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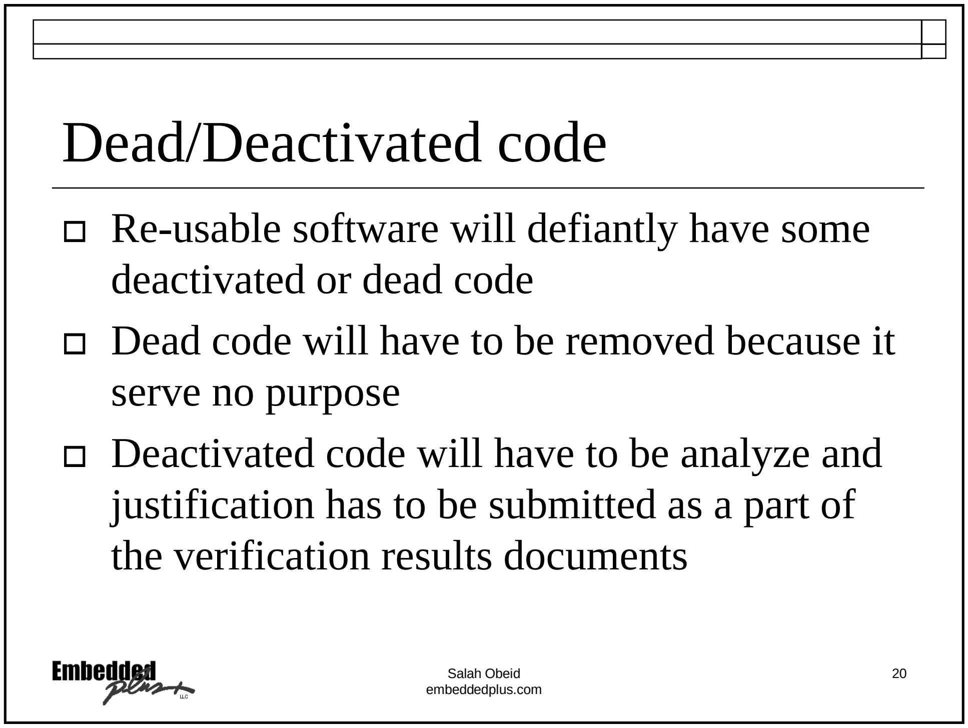

Dead/Deactivated code

- Re-usable software will defiantly have some deactivated or dead code
- Dead code will have to be removed because it serve no purpose
- Deactivated code will have to be analyze and justification has to be submitted as a part of the verification results documents

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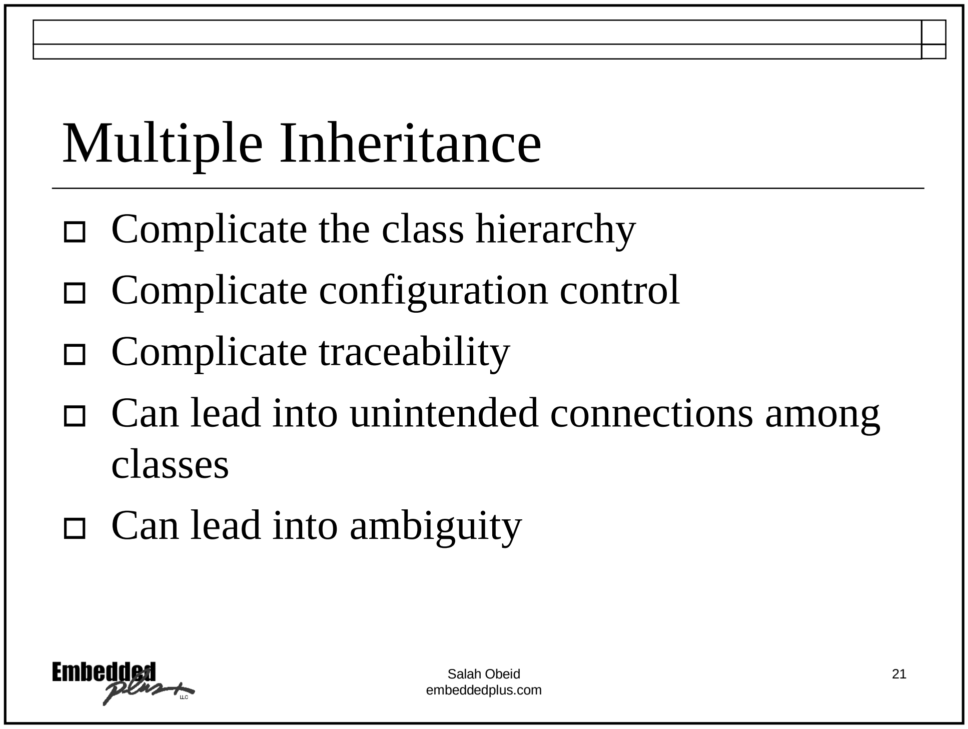

Multiple Inheritance

- □ Complicate the class hierarchy
- □ Complicate configuration control
- □ Complicate traceability
- □ Can lead into unintended connections among classes
- □ Can lead into ambiguity

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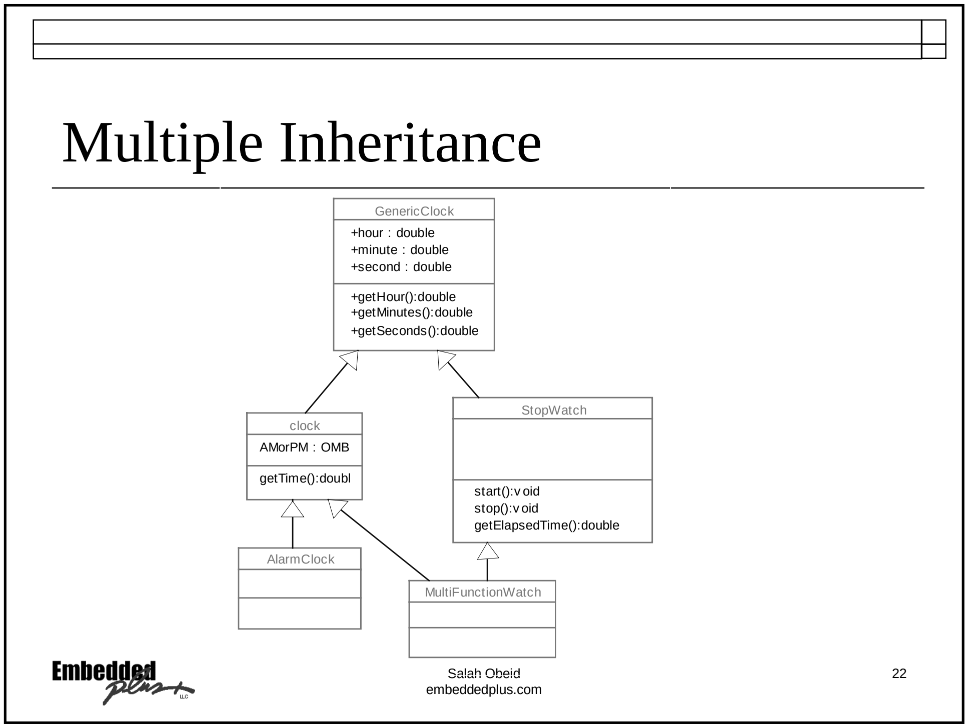

Multiple Inheritance

GenericClock
+hour : double
+minute : double
+second : double
+getHour():double
+getMinutes():double
+getSeconds():double

clock
AMorPM : OMB
getTime():doubl

StopWatch
start():void
stop():void
getElapsedTime():double

AlarmClock

MultiFunctionWatch

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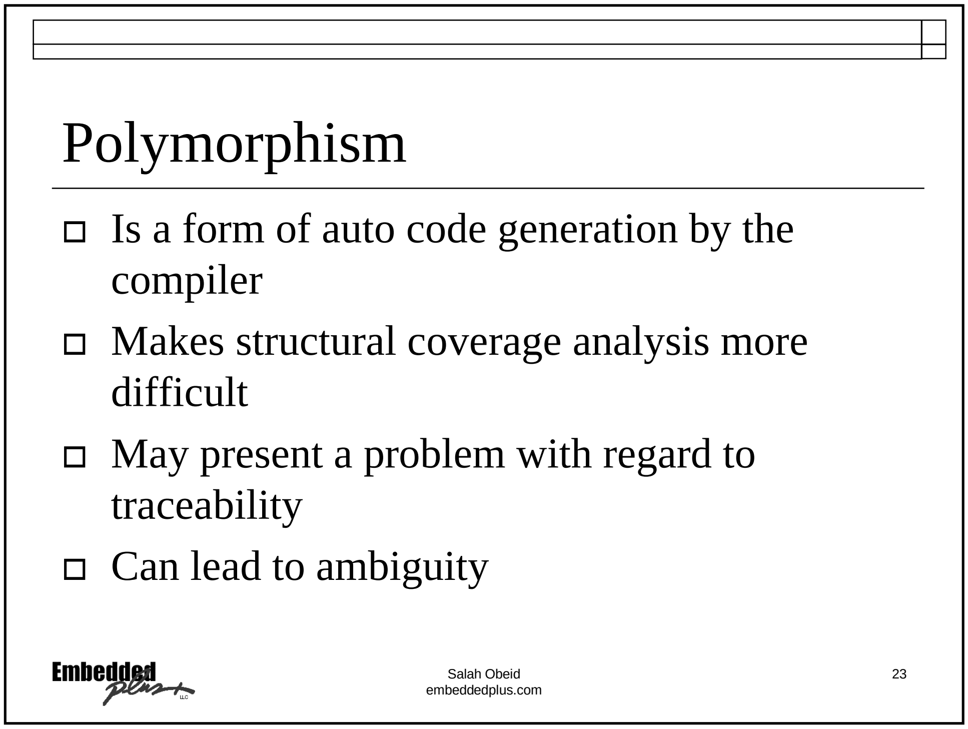

Polymorphism

- □ Is a form of auto code generation by the compiler
- □ Makes structural coverage analysis more difficult
- □ May present a problem with regard to traceability
- □ Can lead to ambiguity

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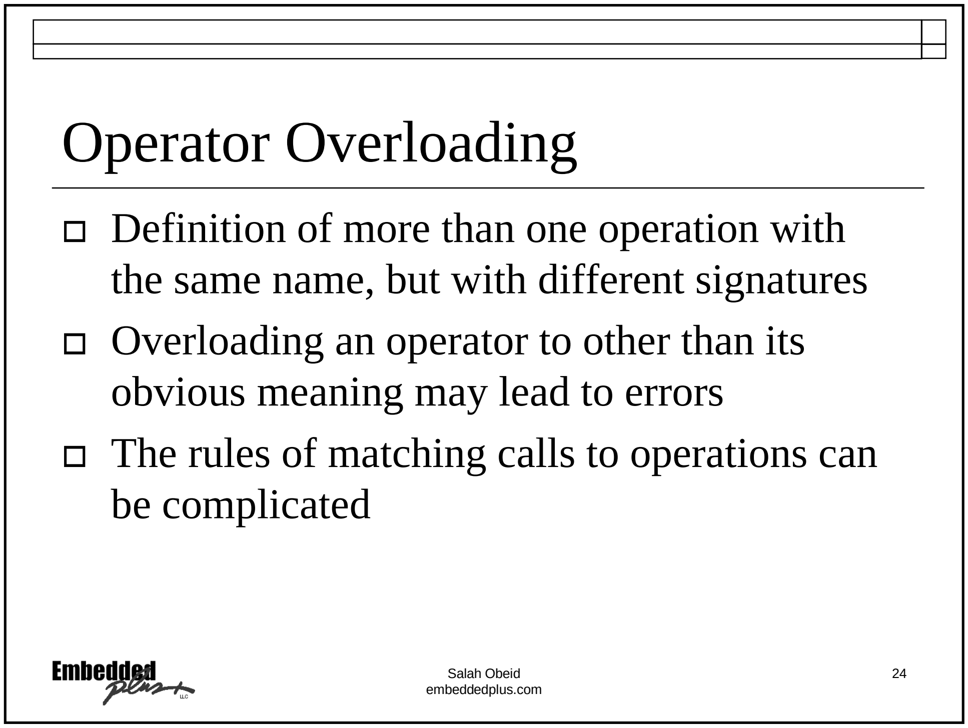

Operator Overloading

- □ Definition of more than one operation with the same name, but with different signatures
- □ Overloading an operator to other than its obvious meaning may lead to errors
- □ The rules of matching calls to operations can be complicated

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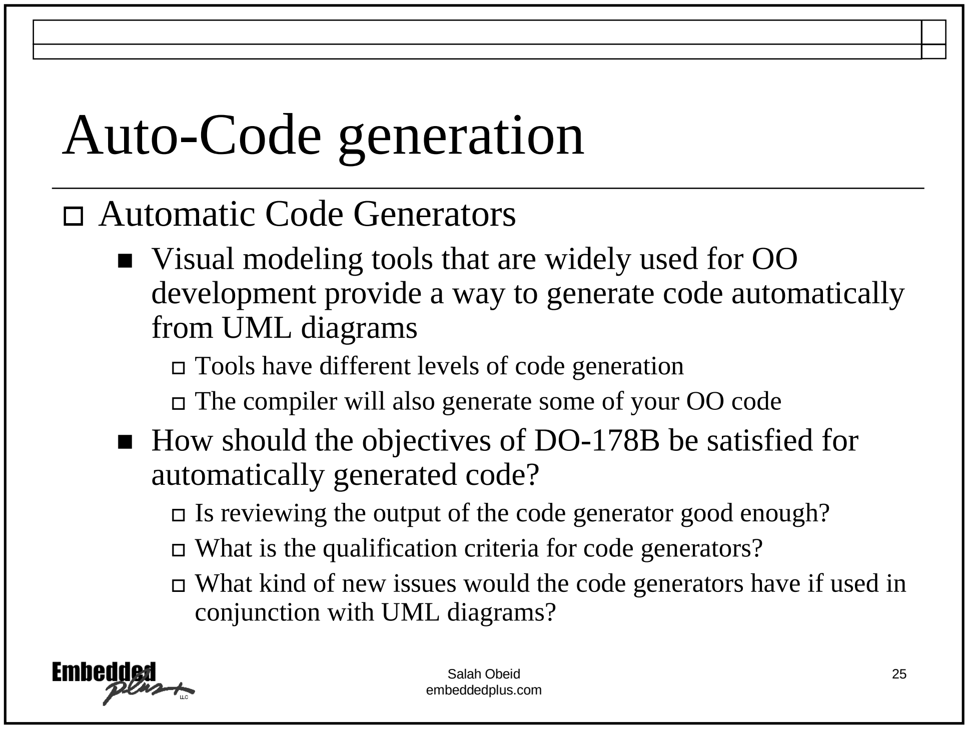

Auto-Code generation

- □ Automatic Code Generators
  - ■ Visual modeling tools that are widely used for OO development provide a way to generate code automatically from UML diagrams
    - □ Tools have different levels of code generation
    - □ The compiler will also generate some of your OO code
  - ■ How should the objectives of DO-178B be satisfied for automatically generated code?
    - □ Is reviewing the output of the code generator good enough?
    - □ What is the qualification criteria for code generators?
    - □ What kind of new issues would the code generators have if used in conjunction with UML diagrams?

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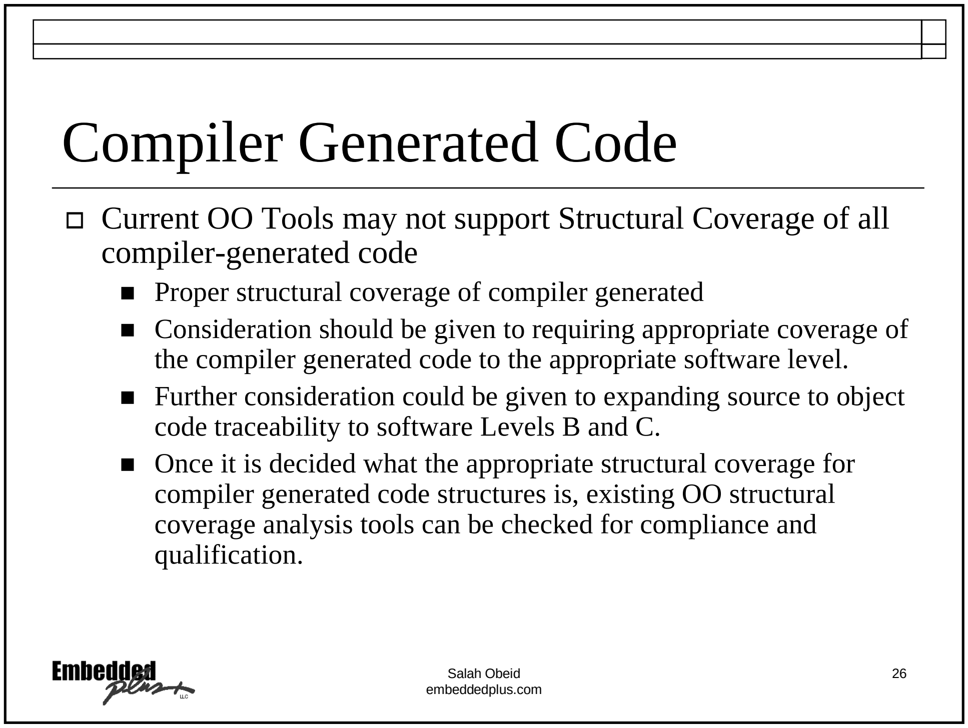

Compiler Generated Code

- □ Current OO Tools may not support Structural Coverage of all compiler-generated code
  - ■ Proper structural coverage of compiler generated
  - ■ Consideration should be given to requiring appropriate coverage of the compiler generated code to the appropriate software level.
  - ■ Further consideration could be given to expanding source to object code traceability to software Levels B and C.
  - ■ Once it is decided what the appropriate structural coverage for compiler generated code structures is, existing OO structural coverage analysis tools can be checked for compliance and qualification.

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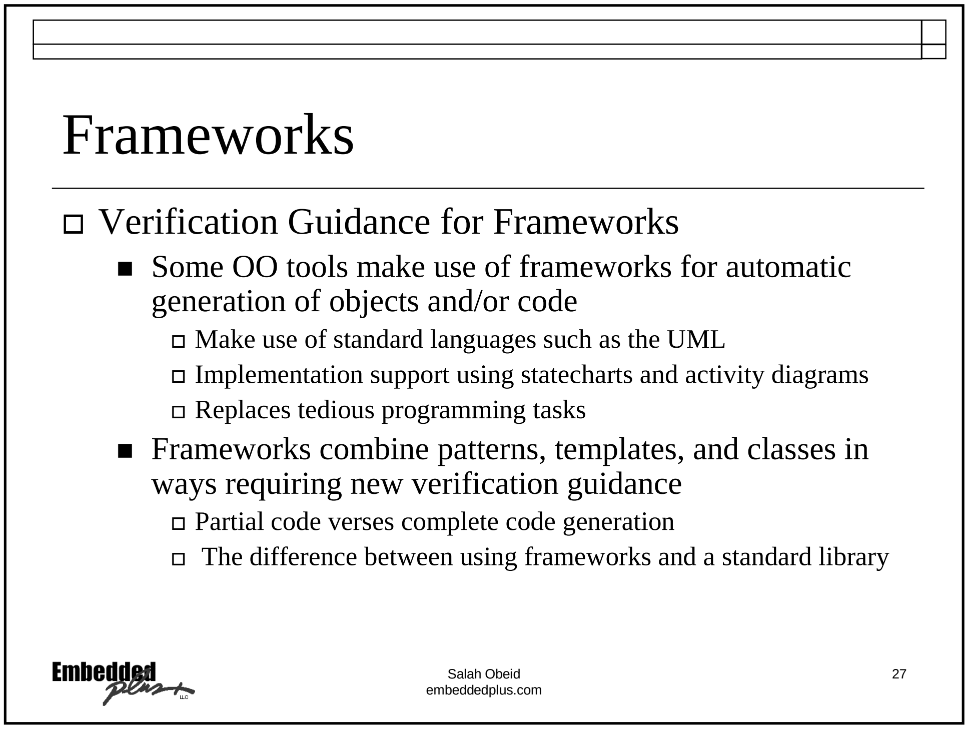

Frameworks

- □ Verification Guidance for Frameworks
  - ■ Some OO tools make use of frameworks for automatic generation of objects and/or code
    - □ Make use of standard languages such as the UML
    - □ Implementation support using statecharts and activity diagrams
    - □ Replaces tedious programming tasks
  - ■ Frameworks combine patterns, templates, and classes in ways requiring new verification guidance
    - □ Partial code verses complete code generation
    - □ The difference between using frameworks and a standard library

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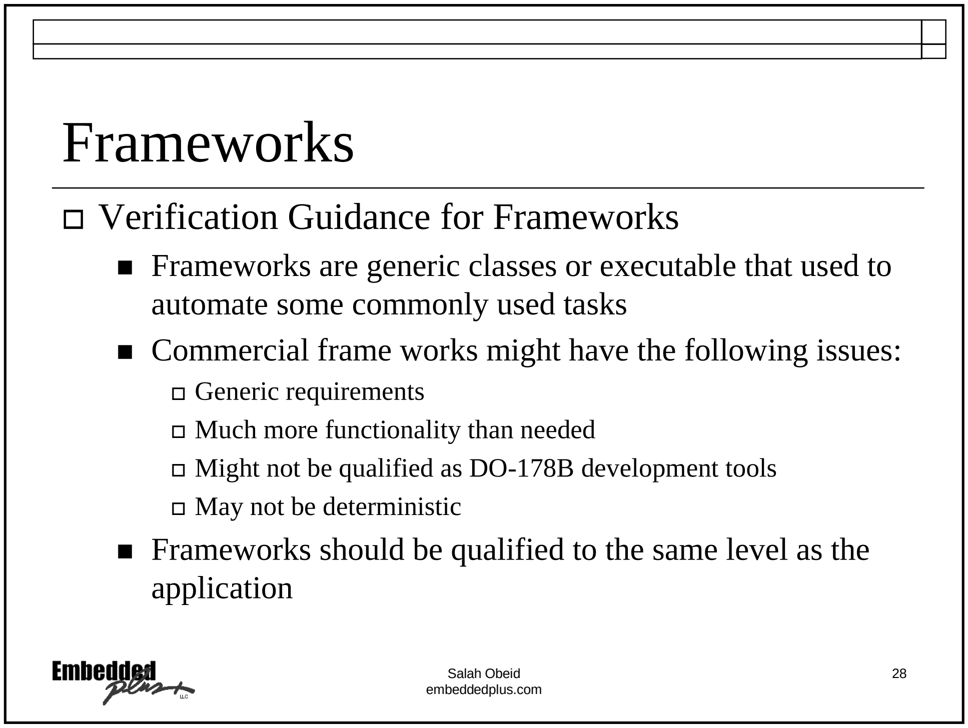

Frameworks

- □ Verification Guidance for Frameworks
  - ■ Frameworks are generic classes or executable that used to automate some commonly used tasks
  - ■ Commercial frame works might have the following issues:
    - □ Generic requirements
    - □ Much more functionality than needed
    - □ Might not be qualified as DO-178B development tools
    - □ May not be deterministic
  - ■ Frameworks should be qualified to the same level as the application

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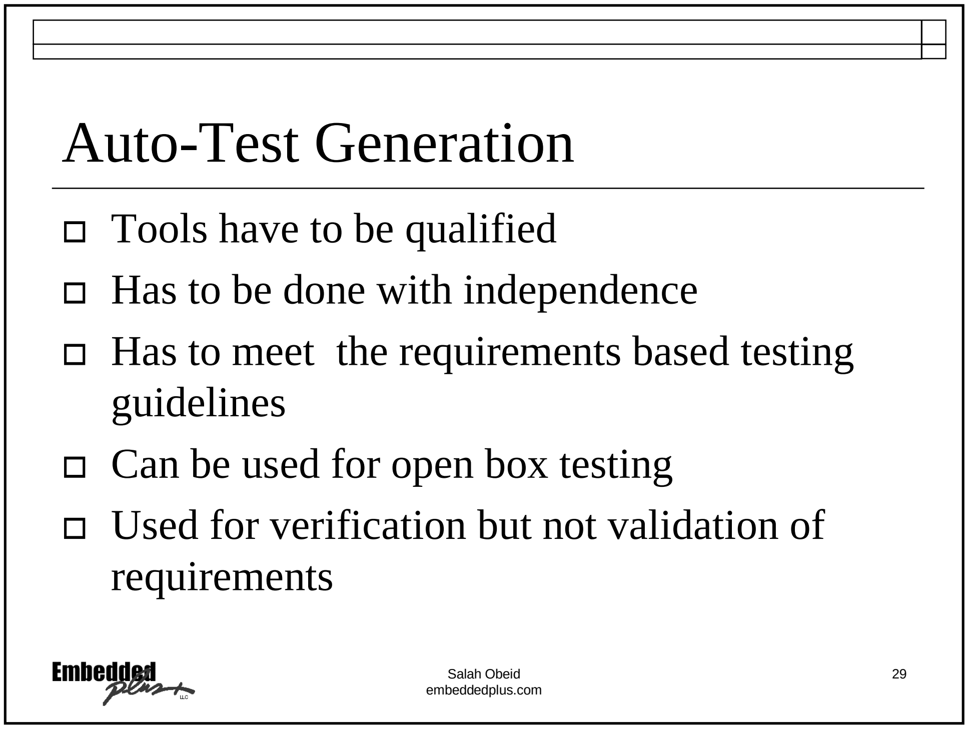

Auto-Test Generation

- □ Tools have to be qualified
- □ Has to be done with independence
- □ Has to meet the requirements based testing guidelines
- □ Can be used for open box testing
- □ Used for verification but not validation of requirements

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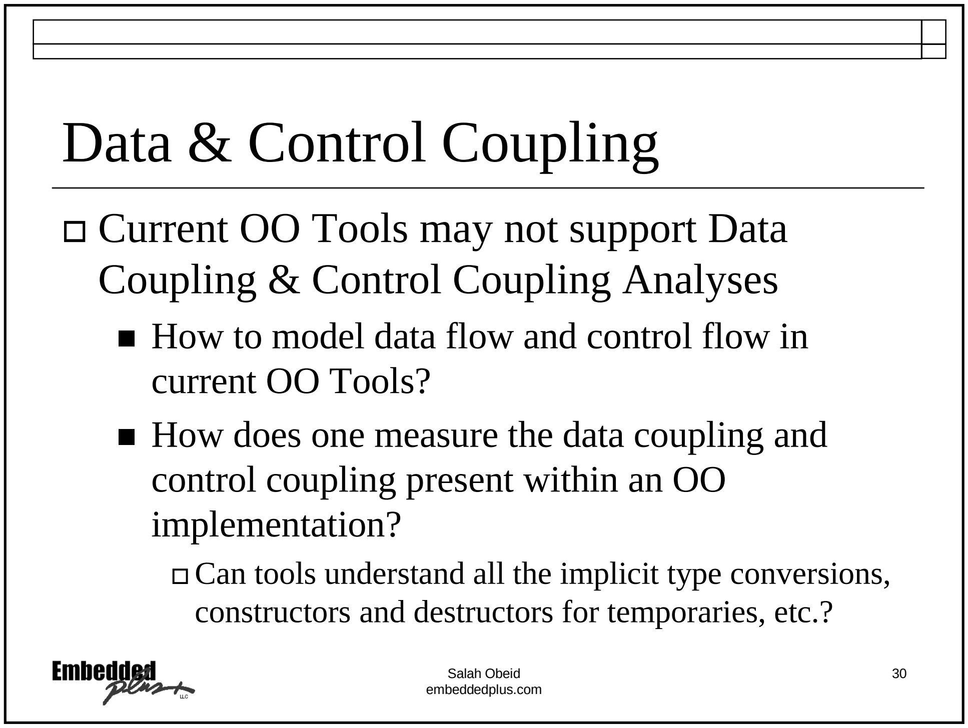

Data & Control Coupling

- □ Current OO Tools may not support Data Coupling & Control Coupling Analyses
  - ■ How to model data flow and control flow in current OO Tools?
  - ■ How does one measure the data coupling and control coupling present within an OO implementation?
    - □ Can tools understand all the implicit type conversions, constructors and destructors for temporaries, etc.?

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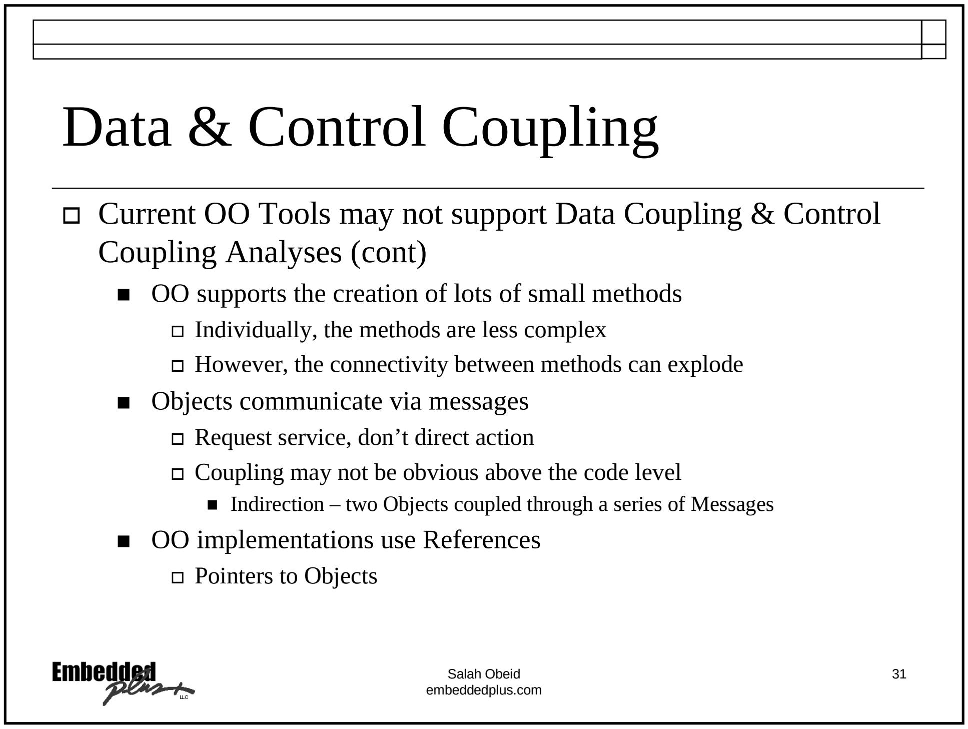

Data & Control Coupling

- □ Current OO Tools may not support Data Coupling & Control Coupling Analyses (cont)
  - ■ OO supports the creation of lots of small methods
    - □ Individually, the methods are less complex
    - □ However, the connectivity between methods can explode
  - ■ Objects communicate via messages
    - □ Request service, don’t direct action
    - □ Coupling may not be obvious above the code level
      - ■ Indirection – two Objects coupled through a series of Messages
  - ■ OO implementations use References
    - □ Pointers to Objects

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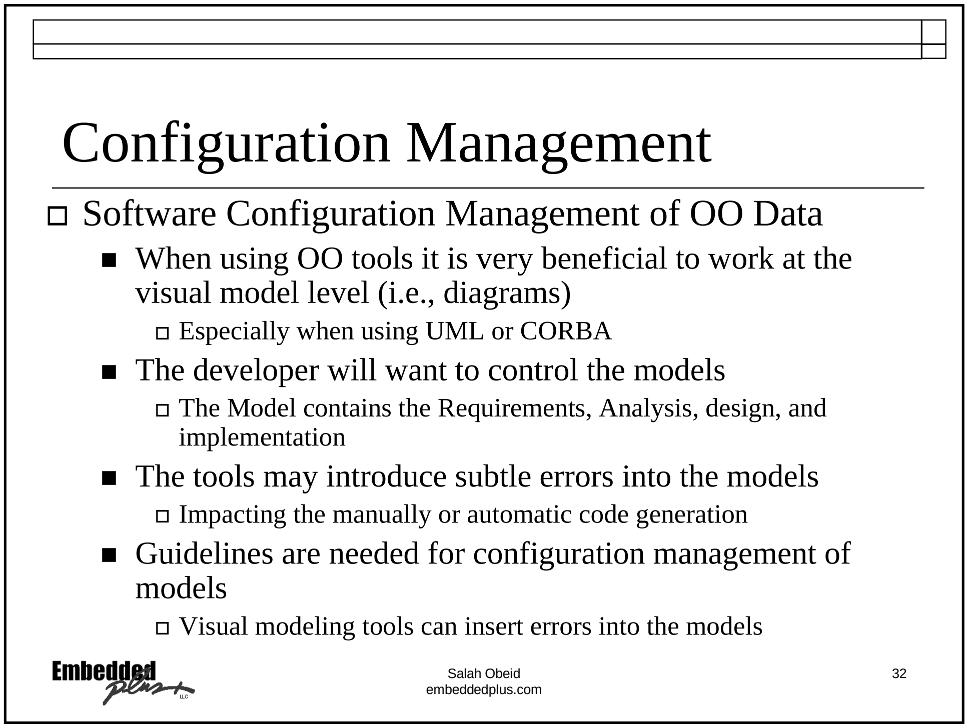

Configuration Management

- □ Software Configuration Management of OO Data
  - ■ When using OO tools it is very beneficial to work at the visual model level (i.e., diagrams)
    - □ Especially when using UML or CORBA
  - ■ The developer will want to control the models
    - □ The Model contains the Requirements, Analysis, design, and implementation
  - ■ The tools may introduce subtle errors into the models
    - □ Impacting the manually or automatic code generation
  - ■ Guidelines are needed for configuration management of models
    - □ Visual modeling tools can insert errors into the models

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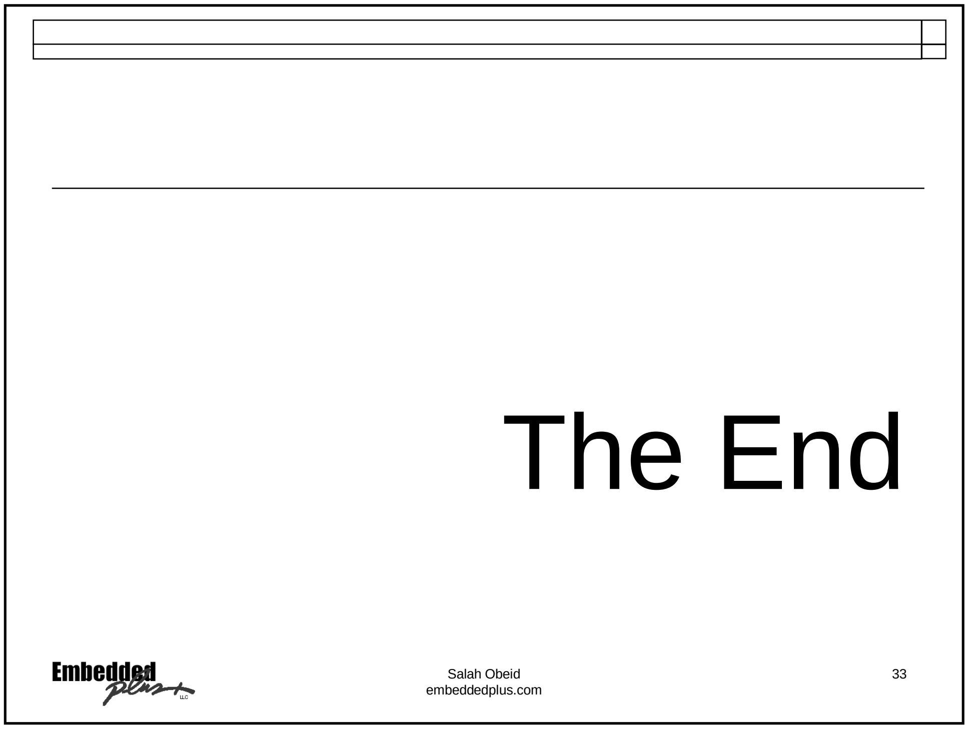

The End

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